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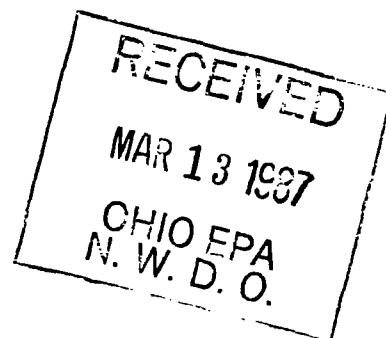
Biological and Water Quality Study of
Raccoon Creek

Sandusky County, Ohio.

February 25, 1987

prepared by

Ohio Environmental Protection Agency
Division of Water Quality Monitoring and Assessment
Surface Water Section
1030 King Ave.
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Ambient Chemical Quality - Steve Dood, Jack Schwartz

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Biological and Water Quality Survey of
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Introduction

Environmental monitoring is an important step in the management and protection of natural resources. Ideally, monitoring is the activity that directs the progression of events from problem identification and assessment, through management decisions on pollution abatement programs, to the enforcement of environmental regulations. This Biological and Water Quality Report represents some of the initial steps in this progression, and as such is one of the technical bases for management decisions within the study area. At the Ohio EPA, the application of monitoring data is primarily related to the management of the pollution abatement programs funded under the Clean Water Act. However, the data contained herein should be applicable to numerous other surface water and natural resource issues. This is made possible by collecting data according to standardized quality assurance procedures and by recording all pertinent information in this document.

General objectives of all biological and water quality evaluations are:

- 1) to determine and measure if adverse impacts on biological condition and water quality occur due to point source discharges or nonpoint sources of pollution;
- 2) to gather data for the evaluation of water quality standard stream use designations (predominantly aquatic life uses), and;
- 3) to define the extent of any impairment of aquatic life or other uses of the surface waters monitored in the study area.

The Raccoon Creek study area extended from upstream from Clyde (RM 13.2) downstream to where the influence of the level of Lake Erie is first evident (RM 3.1).

Specific objectives of this evaluation were to:

- 1) evaluate the impact from the Whirlpool Corp.- Clyde facility following changes made to the process wastewater discharge;
- 2) evaluate the instream effect of any toxicity observed in effluent bioassay tests conducted on the Whirlpool effluent; and,
- 3) compare the results to those observed in 1983.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (e.g. NPDES permits) and eventually be incorporated into the State water quality management plans and biennial 305(b) report.

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The Raccoon Creek study area was surveyed in 1983 for the purpose of evaluating the need for advanced treatment (AT) at the Clyde WWTP. The results and analysis of this effort are contained in the 1984 Water Quality Technical Support Document for Raccoon Creek (Ohio EPA 1984a). The follow-up work in 1986 was prompted by the need for information to support the development of water quality-based effluent limits, including any applicable toxicity considerations, for the Whirlpool Corp.- Clyde discharge. In addition, changes in the 001 process wastewater discharge were made since the 1983 survey. Thus an additional objective was to evaluate the result of these changes. Other pollution sources in the study area include the Clyde WWTP, combined sewer overflows from Clyde, septic inputs, and nonpoint sources.

Study Area

Biological and grab chemical samples were collected from seven stream locations between River Mile (RM) 13.2 and 3.1 upstream and downstream from the Village of Clyde in 1986. In addition grab chemical samples were collected from Whirlpool-Clyde 001 and Clyde WWTP 001 outfalls. Sediment samples were collected from three locations (RM 13.2, 10.2, and 3.1). Stream sampling locations were positioned to provide a longitudinal profile of the biological and chemical results so that the magnitude (distance downstream) and severity (degree of degradation) of any observed impacts could be evaluated. A detailed description of the Raccoon Creek study area is contained in Ohio EPA (1984a). Further details about sampling locations, methods, and results are contained in the attached tables and figures.

Results and Discussion

Detailed results of the grab chemical, sediment, effluent, macroinvertebrate, and fish components of the survey are contained in the attachments. A severe biological and chemical impact was observed immediately downstream from the Whirlpool facility. These results indicate little overall change from that observed in 1983 (Ohio EPA 1984a). Highlights of the findings are:

Chemical, Sediment, and Effluent Sampling

- High levels of nitrogenous compounds were observed downstream from Whirlpool and the Clyde WWTP. Nitrite-N was very high in the Whirlpool effluent and remained above 0.5 mg/l in Raccoon Creek downstream to RM 6.5. The Clyde WWTP was the principal source of ammonia-N.
- Dissolved oxygen levels were very low (minimums less than 2-3 mg/l) from immediately downstream from Whirlpool to RM 10.2 (first site downstream Clyde WWTP). Steady recovery was observed from this point to RM 3.2 where all values exceeded 4 mg/l.
- Metals results showed elevated levels of nickel and copper downstream from the Whirlpool discharge. The elevated copper level (130 ug/l) at RM 13.2 (upstream from Whirlpool and the Clyde WWTP) on July 23 is unexplained.
- Lead and zinc were found in highly elevated concentrations in sediments at RM 10.2 the closest of two sites downstream from the point sources. All other parameters were in non-elevated concentrations at this and two other sites.

Physical Stream Habitat

- Raccoon Creek offers a small stream habitat with good pool-riffle development between RM 13.2 and RM 3.7. Few areas of recent channel modification were evident. However, a portion of the stream channel is completely covered by the Whirlpool facility in Clyde and the RM 11.7 location is extensively rip-rapped.
- The lower 3-4 miles of Raccoon Creek are affected by the level of Sandusky Bay and Lake Erie which results in a flooded river mouth habitat.
- QHEI (Qualitative Habitat Evaluation Index) scores ranged from 52 at RM 8.6 to 72 at RM 13.2 which indicates fair to good habitat conditions for aquatic life.

Macroinvertebrates

- Results showed essentially no change downstream from the Whirlpool facility between 1983 and 1986. Severe degradation was observed during both years.
- Between 1983 and 1986 some marginal improvement was noted downstream from RM 10.1. This was attributed to better water quality conditions in Buck Creek (RM 10.1) in 1986, not to improved conditions at the two point sources. Indications of less significant water quality problems in Buck Creek still remain compared to 1983.
- The effect of intermittent flow conditions were evident in the results at RM 13.2, but water quality appeared adequate for sustaining invertebrates along the water line margin.
- Recovery was not complete at the farthest downstream location.

Fish

- A larger difference between the conventional composite index and modified composite index¹ values was observed at the two upstream sites in 1986 as compared to 1983. This was attributed to the lower relative numbers of tolerant fish species captured in 1986. The lower flow conditions in 1986 compared to 1983 were apparently responsible for these results.
- A severe toxic impact was indicated by the 1986 results, much the same as in 1983, immediately downstream from the Whirlpool facility. Both modified and conventional composite index values increased steadily downstream to RM 3.7.
- Minor influences from intermittent stream flow and combined sewer overflow inputs were noted at RM 13.2 and 11.6.

1 The modified composite index removes any of 13 highly tolerant fish species from the numbers and biomass components of the composite index.

- Recovery from the point source dominated impacts was not complete at RM 3.7.
- Habitat did not play a major role in the observed fish community response downstream from the point sources. This contention is supported by the lack of a positive correlation between the fish results and the Qualitative Habitat Evaluation Index (QHEI).

Other

- Both the fish and macroinvertebrate communities were typical of small, headwater streams in the upper part of the study area (RM 13.2 and 11.6) and were influenced more by intermittent stream flows and limited habitat than water quality. The potential for a more diverse biota increased downstream with increasing stream size.

The Warmwater Habitat use is impaired for a minimum distance of eight miles between RM 11.2 and 3.2. The predominant negative influence in the study area is the Whirlpool Corp.- Clyde facility discharge. No negative effect from the Clyde WWTP was apparent in the biological results. This is due to the pervasiveness of the toxic impact from Whirlpool, not the lack of potential for negative impact from the Clyde WWTP. The key to full attainment of the WWH use is reducing inputs from Whirlpool and attainment of AT limits at the Clyde WWTP.

Although the instream biological and bioassay results both show the effects of significant toxicity the current and future effect of low D.O. should also be considered. Thus any efforts to reduce toxicity should also be accompanied by an effort to reduce loadings of oxygen demanding wastes. This should be accomplished if the wasteload allocation recommendations of the unpublished 1984 CWQR are followed.

Recommendations

The Whirlpool-Clyde facility must reduce inputs of toxic materials into Raccoon Creek. This includes limiting nitrogenous compounds (particularly nitrite-N) and metals (nickel and copper). This may involve developing an effluent limit for nitrite-N which will prompt the need to calculate a water quality criterion value for this parameter. Toxic units limits may also be necessary. Consideration should also be given to the limits recommended for BOD_5 (and other related parameters) in the unpublished 1984 CWQR.

The Clyde WWTP is currently upgrading to advanced treatment levels thus no further requirements are necessary at this time. Impacts from other sources were either minor or not detected, thus requiring no further recommendations.

RECOMMENDATIONS FOR FUTURE MONITORING

As a result of this survey the following recommendations are made for future water quality and biological monitoring in the Raccoon Creek study area.

1. Follow-up biological field work will be necessary after major improvements are made at the Whirlpool and/or Clyde WWTP in order to assess progress toward attainment of the WWH use. This is important given the complexity and magnitude of the problem. Because of these complexities some "trial and error" may have to be accepted in solving the toxicity problem.

REFERENCES

- Kelly, M.H. and R.L. Hite. 1984. Evaluation of Illinois stream sediment data: 1974-1980. Illinois Environmental Protection Agency, Div. of Water Pollution Control. Springfield, IL. 105p.
- Ohio Environmental Protection Agency. 1984a. Raccoon Creek Comprehensive Water Quality Report - Raccoon Creek Subbasin Sandusky County, Ohio. State of Ohio Environmental Protection Agency, Columbus, Ohio.
- Ohio Environmental Protection Agency. 1984b. Ohio EPA manual of surveillance methods and quality assurance practices, updated edition. Division of Water Quality Monitoring and Assessment, Evaluation and Standards Section, Columbus, Ohio.

Chemical/Physical Water Quality Sampling Methods

Chemical water quality samples and measurements were taken three times at seven localities in the Raccoon Creek study area during the period July-September, 1986. Effluent from Whirlpool-Clyde and the Clyde WWTP was also collected. Sediment samples were taken at three sites on November 3, 1986. Conductivity, dissolved oxygen, and temperature were measured in the field with YSI Model 33 and 57 meters. A Corning 620 meter was used to determine instantaneous pH in the field. Grab samples for chemical constituents were preserved and analyzed according to the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 1984b). Analyses were performed by the Ohio EPA Water Quality Laboratory in Columbus. Parameters monitored are listed in Table 1.

Table C-1. Chemical/physical parameters measured in the Raccoon Creek study area, 1986.

Temperature	Aluminum, Total Recoverable (Al-TR)
Dissolved Oxygen (D.O.)	Barium, Total Recoverable (Ba-TR)
pH	Calcium, Total Recoverable (Ca-TR)
Conductivity	Chromium, Total Recoverable (Cr-TR)
Flow	Copper, Total Recoverable (Cu-TR)
Biochemical Oxygen Demand (BOD_5)	Iron, Total Recoverable (Fe-TR)
Ammonia-Nitrogen ($\text{NH}_3\text{-N}$)	Lead, Total Recoverable (Pb-TR)
Nitrate-Nitrogen ($\text{NO}_3\text{-N}$)	Magnesium, Total Recoverable (Mg-TR)
Nitrite-Nitrogen ($\text{NO}_2\text{-N}$)	Nickel, Total Recoverable (Ni-TR)
Total Kjeldahl Nitrogen (TKN)	Zinc, Total Recoverable (Zn-TR)
Phosphorus, Total (P-T)	Residue, Total Filterable (TDS)
Hardness, Total (CaCO_3)	Residue, Total Nonfilterable (TSS)
Fecal Coliform (Fecal coliform)	Oil and Grease (O&G)

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Table C-2. Third-quarter (July-September) average flows (million gallons/day, MGD) and pollutant loadings (kilograms/day, KGD) from permitted point source discharges in the Raccoon Creek study area during 1981 through 1986.

Source (Permit Number) ^a & Outfall No.	Parameter	Year						
		1981	1982	1983	1984	1985	1986	
Whirlpool Corp. (2IC00008)								
001 Effluent								
Flow	0.202	0.243	0.249	0.274	0.295	0.312	0.312	
Biochemical Oxygen Demand (5-day)	24.3	58.7	48.7	57.2	45.9	56.0	56.0	
Total Suspended Solids	13.3	18.2	12.0	19.1	17.5	14.3	14.3	
Oil and Grease	2.2	4.2	4.5	9.9	5.1	4.4	4.4	
Iron-Total	0.194	0.275	0.194	0.185	0.292	0.358	0.358	
Nickel-Total	0.457	0.344	0.597	0.496	0.568	0.608	0.608	
Zinc-Total	-	0.077	0.197	0.046	0.198	0.151	0.151	
Chemical Oxygen Demand	-	179.6	248.3	250.8	200.2	273.0	273.0	
Phosphorus-Total	-	0.949	0.971	0.620	3.248	4.496	4.496	
Chromium-Total	-	0.016	0.033	0.028	0.109	0.084	0.084	
002 Noncontact cooling water								
Flow	0.032	0.024	0.023	0.029	0.007	0.021	0.021	
003 Wash machine test water								
Flow	0.013	0.012	0.023	0.012	0.009	0.042	0.042	
Clyde WWTP (2PD00004)								
001 Final Effluent								
Flow	1.358	0.907	0.706	0.621	0.765	1.141	1.141	
Biochemical Oxygen Demand (5-day)	78.1	76.2	54.8	61.0	67.7	70.5	70.5	
Chemical Oxygen Demand	551.3	450.4	286.2	480.1	594.2	526.2	526.2	
Total Suspended Solids	34.7	48.7	23.6	19.7	31.6	58.2	58.2	
Oil and Grease	13.5	7.0	4.7	4.0	2.7	8.1	8.1	
Ammonia-N	65.4	50.7	35.8	53.3	44.3	37.8	37.8	
Nitrite-N	1.47	0.89	0.75	0.65	3.66	0.144	0.144	
Nitrate-N	26.2	15.3	9.2	6.6	6.8	14.9	14.9	
Phosphorus-T	27.5	20.4	11.7	15.2	19.4	24.7	24.7	
Cadmium-T	0.019	0.032	0.016	0.009	0.009	0.017	0.017	
Chromium-T	0.051	0.033	0.074	0.023	0.029	0.042	0.042	
Copper-T	0.060	0.065	0.030	0.056	0.060	0.134	0.134	
Lead-T	0.157	0.151	0.076	0.053	0.076	0.092	0.092	
Nickel-T	0.086	0.033	0.031	0.026	0.029	0.055	0.055	
Zinc-T	0.168	0.097	0.064	0.069	0.100	0.193	0.193	
Chlorine-TR	0.563	0.597	0.503	0.630	0.680	0.693	0.693	
Mercury-T	0.001	0.001	0.001	0.002	0.001	0.001	0.001	
Carbonaceous BOD ₅	-	-	-	52.2	58.0	58.7	58.7	

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Table C-4. Results of chemical/physical data collected from the Raccoon Creek study area, 1986. The R column denotes samples stored with remark codes. The K remark denotes values which are below laboratory detection limits. The T remark denotes the total summary of values stored with and without remark codes.

STORET STATION NUMBER U05W19								
LATITUDE/LONGITUDE 41 24 27/82 58 55								
RACCOON CREEK NW OF VICKERY - S.R. 6								
RIVER MILE 3.08								
PARAMETER			R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM
WATER TEMP	CENT		R	3	18.03300	2.484700	20.9	16.5 86/07 86/09
CNDUCTVY AT 25C	MICROMHO		R	3	1540.000	291.0300	1870	1320 86/07 86/09
DO PROBE	MG/L		R	3	6.000000	.7550600	6.8	5.3 86/07 86/09
COD LOWLEVEL	MG/L		R	2	32.00000	5.656900	36.0	28.0 86/08 86/09
PH	SU		R	3	7.100000	.4001700	7.50	6.70 86/07 86/09
RESIDUE TOT NFLT	MG/L		R	3	13.66700	8.082900	23	9 86/07 86/09
OIL--GRSE FREON-GR	MG/L		R	1	2.790000		2.79	2.79 86/07 86/07
NH3+NH4- N TOTAL	MG/L		R	3	.1166700	.0305510	.150	.090 86/07 86/09
NO2-N TOTAL	MG/L		R	3	.1233300	.0873690	.220	.050 86/07 86/09
TOT KJEL N	MG/L		R	3	.9666700	.3055100	1.300	.700 86/07 86/09
NO2&NO3 N-TOTAL	MG/L		R	3	1.676700	.3962800	2.09	1.30 86/07 86/09
PHOS-TOT	MG/L P		R	3	.9966700	.5666000	1.650	.640 86/07 86/
TOT HARD CACO3	MG/L		R	3	763.0000	168.8800	958	664 86/07 86/
CALCIUM CA-TOT	MG/L		R	3	242.3300	54.50100	305.0	206.0 86/07 86/09
MGNSIUM MG,TOT	MG/L		R	3	38.30000	8.576800	47.7	30.9 86/07 86/09
BARIUM BA,TOT	UG/L	K	R	3	200.0000	.0000000	200	200 86/07 86/09
CHROMIUM CR,TOT	UG/L	K	R	3	30.00000	.0000000	30	30 86/07 86/09
COPPER CU,TOT	UG/L		R	2	22.50000	10.60700	30	15 86/07 86/09
		K	R	1	10.00000		10	10 86/08 86/08
		T	R	3	18.33300	10.40800	30	10 86/07 86/09
IRON FE,TOT	UG/L		R	3	713.3300	291.6100	1050	540 86/07 86/09
LEAD PB,TOT	UG/L	K	R	3	2.000000	.0000000	2	2 86/07 86/09
NICKEL NI,TOTAL	UG/L	K	R	3	40.00000	.0000000	40	40 86/07 86/09
ZINC ZN,TOT	UG/L		R	2	17.50000	3.535500	20	15 86/07 86/09
		K	R	1	10.00000		10	10 86/08 86/08
		T	R	3	15.00000	5.000000	20	10 86/07 86/09
ALUMINUM AL,TOT	UG/L		R	3	620.0000	140.0000	780	520 86/07 86/09
RESIDUE DISS-180 C	MG/L		R	3	1240.000	240.2100	1510	1050 86/07 86/09

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Table C-4 (Continued).

STORET STATION NUMBER U05W16
 LATITUDE/LONGITUDE 41 22 00/82 59 22
 RACCOON CREEK NORTH OF CLYDE - S.R. 412
 RIVER MILE 6.53

PARAMETER		R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END	
WATER	TEMP	CENT	3	17.13300	2.138700	19.6	15.8	86/07	86/07	
CNDUCTVY	AT 25C	MICROMHO	3	1556.700	98.16800	1670	1500	86/07	86/07	
DO	PROBE	MG/L	3	4.600000	.5291400	5.2	4.2	86/07	86/07	
PH		SU	3	6.933300	.2312000	7.20	6.80	86/07	86/07	
NH3+NH4-	N TOTAL	MG/L	3	.9800000	1.158800	2.300	.130	86/07	86/09	
NO2-N	TOTAL	MG/L	3	.4533300	.2122100	.690	.280	86/07	86/09	
TOT KJEL	N	MG/L	3	2.100000	1.253000	3.400	.900	86/07	86/09	
NO2&NO3	N-TOTAL	MG/L	3	2.076700	.1266300	2.22	1.98	86/07	86/09	
TOT HARD	CACO3	MG/L	3	1224.000	718.2900	2050	746	86/07	86/09	
CALCIUM	CA-TOT	MG/L	3	250.0000	29.13800	282.0	225.0	86/07	86/09	
MGNSIUM	MG,TOT	MG/L	3	37.20000	4.092700	41.7	33.7	86/07	86/09	
COPPER	CU,TOT	UG/L	1	20.00000		20	20	86/07	86/07	
		K	2	10.00000	.0000000	10	10	86/08	86/09	
		T	3	13.33300	5.773500	20	10	86/07	86/09	
NICKEL	NI,TOTAL	UG/L	K	3	40.00000	.0000000	40	40	86/07	86/09
ZINC	ZN,TOT	UG/L	2	15.00000	.0000000	15	15	86/07	86/09	
		K	1	10.00000		10	10	86/08	86/08	
		T	3	13.33300	2.886800	15	10	86/07	86/09	

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Table C-4 (Continued).

STORET STATION NUMBER U05W13
 LATITUDE/LONGITUDE 41 20 33/83 00 18
 RACCOON CREEK E OF FREMONT - CO. RD. 229
 RIVER MILE 8.66

PARAMETER		R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END	
WATER	TEMP	CENT	3	19.46700	1.975700	21.6	17.7	86/07	86/09	
CNDUCTVY	AT 25C	MICROMHO	3	1046.300	179.8400	1160	839	86/07	86/09	
DO	PROBE	MG/L	3	3.766700	.3785800	4.2	3.5	86/07	86/09	
BOD	5 DAY	MG/L	1	12.00000		12.0	12.0	86/07	86/07	
BOD	20 DAY	MG/L	1	53.00000		53.0	53.0	86/07	86/07	
COD	LOWLEVEL	MG/L	3	53.33300	11.24000	63.0	41.0	86/07	86/09	
PH		SU	3	7.200000	.4583100	7.70	6.80	86/07	86/09	
RESIDUE	TOT NFLT	MG/L	2	7.500000	3.535500	10	5	86/07	86/09	
			K	1	5.000000	5	5	86/08	86/08	
			T	3	6.666700	2.886800	10	5	86/07	86/09
OIL-GRSE	FREON-GR	MG/L	1	1.710000		1.71	1.71	86/07	86/07	
NH3+NH4-	N TOTAL	MG/L	3	3.703300	1.410600	5.090	2.270	86/07	86/09	
N02-N	TOTAL	MG/L	3	.9533300	.2967100	1.230	.640	86/07	86/09	
TOT KJEL	N	MG/L	3	5.800000	1.997500	7.500	3.600	86/07	86/09	
N02&N03	N-TOTAL	MG/L	3	2.360000	.6269800	2.87	1.66	86/07	86/Q9	
PHOS-TOT		MG/L P	3	2.416700	1.895000	4.600	1.200	86/07	86/	
TOT HARD	CACO3	MG/L	3	307.0000	61.61200	377	261	86/07	86/09	
CALCIUM	CA-TOT	MG/L	3	86.36700	20.46800	110.0	74.4	86/07	86/09	
MGNSIUM	MG,TOT	MG/L	3	22.20000	3.500000	24.7	18.2	86/07	86/09	
BARIUM	BA,TOT	UG/L	K	3	200.0000	.0000000	200	200	86/07	86/09
CHROMIUM	CR,TOT	UG/L	K	3	30.00000	.0000000	30	30	86/07	86/09
COPPER	CU,TOT	UG/L		1	20.00000		20	20	86/07	86/07
			K	2	10.00000	.0000000	10	10	86/08	86/09
			T	3	13.33300	5.773500	20	10	86/07	86/09
IRON	FE,TOT	UG/L		3	266.6700	40.41600	290	220	86/07	86/09
LEAD	PB,TOT	UG/L	K	3	2.000000	.0000000	2	2	86/07	86/09
NICKEL	NI,TOTAL	UG/L		2	135.0000	134.3500	230	40	86/08	86/09
			K	1	40.00000		40	40	86/07	86/07
			T	3	103.3300	109.7000	230	40	86/07	86/09
ZINC	ZN,TOT	UG/L		1	15.00000		15	15	86/07	86/07
			K	2	10.00000	.0000000	10	10	86/08	86/09
			T	3	11.66700	2.886800	15	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	K	3	500.0000	,0000000	500	500	86/07	86/09
FEC COLI	MFM-FCBR	/100ML		1	280.0000		280	280	86/07	86/07
RESIDUE	DISS-180 C	MG/L	3	715.3300	111.2600	822	600	86/07	86/09	
BOD	20C 5DAY CAR	MG/L	1	8.400000		8.4	8.4	86/07	86/07	
BOD	20C 20DAYCAR	MG/L	1	26.00000		26.0	26.0	86/07	86/07	

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Table C-4 (Continued).

STORET STATION NUMBER U05W10
 LATITUDE/LONGITUDE 41 19 42/82 59 15
 RACCOON CREEK NORTH OF CLYDE - TWP. RD. 223
 RIVER MILE 10.18

PARAMETER			R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END
WATER	TEMP	CENT		3	20.86700	1.680500	22.7	19.4	86/07	86/09
CONDUCTVY	AT 25C	MICROMHO		3	1123.300	202.0800	1340	940	86/07	86/09
DO	PROBE	MG/L		3	3.066700	.4041500	3.5	2.7	86/07	86/09
BOD	5 DAY	MG/L		1	9.900000		9.9	9.9	86/07	86/07
BOD	20 DAY	MG/L		1	59.00000		59.0	59.0	86/07	86/07
COD	LOWLEVEL	MG/L		3	65.66700	12.09700	75.0	52.0	86/07	86/09
PH		SU		3	7.250000	.5269400	7.80	6.75	86/07	86/09
RESIDUE	TOT NFLT	MG/L		1	5.000000		5	5	86/07	86/07
			K	2	5.000000	.0000000	5	5	86/08	86/09
			T	3	5.000000	.0000000	5	5	86/07	86/09
OIL-GRSE	FREON-GR	MG/L		1	1.490000		1.49	1.49	86/07	86/07
NH3+NH4-	N TOTAL	MG/L		3	4.750000	1.100000	5.850	3.650	86/07	86/09
NO2-N	TOTAL	MG/L		3	1.103300	.8578100	2.020	.320	86/07	86/09
TOT KJEL	N	MG/L		3	7.166700	1.665400	8.500	5.300	86/07	86/09
NO2&NO3	N-TOTAL	MG/L		3	2.203300	1.840500	4.02	.34	86/07	86/09
PHOS-TOT		MG/L P		3	2.226700	1.106400	3.500	1.500	86/07	86/09
TOT HARD	CACO3	MG/L		3	280.6700	35.53200	321	254	86/07	86/09
CALCIUM	CA-TOT	MG/L		3	75.90000	15.65000	93.1	62.5	86/07	86/09
MGNSIUM	MG,TOT	MG/L		3	22.16700	1.343000	23.7	21.2	86/07	86/09
BARIUM	BA,TOT	UG/L	K	3	200.0000	.0000000	200	200	86/07	86/09
CHROMIUM	CR,TOT	UG/L	K	3	30.00000	.0000000	30	30	86/07	86/09
COPPER	CU,TOT	UG/L		1	10.00000		10	10	86/08	86/08
			K	2	10.00000	.0000000	10	10	86/07	86/09
			T	3	10.00000	.0000000	10	10	86/07	86/09
IRON	FE,TOT	UG/L		3	246.6700	46.18900	300	220	86/07	86/09
LEAD	PB,TOT	UG/L	K	3	2.000000	.0000000	2	2	86/07	86/09
NICKEL	NI,TOTAL	UG/L		3	120.0000	130.0000	270	40	86/07	86/09
ZINC	ZN,TOT	UG/L		1	20.00000		20	20	86/07	86/07
			K	2	10.00000	.0000000	10	10	86/08	86/09
			T	3	13.33300	5.773500	20	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	K	3	500.0000	.0000000	500	500	86/07	86/09
FEC COLI	MFM-FCBR	/100ML		1	480.0000		480	480	86/07	86/07
RESIDUE	DISS-180 C	MG/L		3	738.6700	119.0400	856	618	86/07	86/09
BOD 20C	5DAY CAR	MG/L		1	9.300000		9.3	9.3	86/07	86/07
BOD 20C	20DAYCAR	MG/L		1	25.00000		25.0	25.0	86/07	86/07

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Table C-4 (Continued).

STORET STATION NUMBER U05W07
 LATITUDE/LONGITUDE 41 19 02/82 59 09
 CLYDE WWTP 001 OUTFALL TO RACCOON CREEK
 RIVER MILE 11.00

PARAMETER			R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END
WATER	TEMP	CENT		3	22.86700	1.582400	24.6	21.5	86/07	86/09
CNDUCTVY	AT 25C	MICROMHO		4	913.0000	83.07000	989	823	86/07	86/09
DO	PROBE	MG/L		3	6.766700	.4042400	7.2	6.4	86/07	86/09
BOD	5 DAY	MG/L		2	19.00000	4.242600	22.0	16.0	86/07	86/09
COD	LOWLEVEL	MG/L		4	97.75000	18.19100	112.0	72.0	86/07	86/09
PH		SU		3	7.166700	.3788000	7.60	6.90	86/07	86/09
RESIDUE	TOT NFLT	MG/L		3	10.00000	6.245000	17	5	86/07	86/09
			K	1	5.000000		5	5	86/08	86/08
			T	4	8.750000	5.678900	17	5	86/07	86/09
OIL-GRSE	FREON-GR	MG/L		1	1.770000		1.77	1.77	86/07	86/07
NH3+NH4-	N TOTAL	MG/L		4	8.537500	1.834200	9.950	5.850	86/07	86/09
NO2-N	TOTAL	MG/L		4	.2250000	.0310910	.260	.190	86/07	86/09
TOT KJEL	N	MG/L		4	15.25000	4.500000	19.000	9.000	86/07	86/09
NO2&NO3	N-TOTAL	MG/L		4	3.492500	.8296400	4.25	2.74	86/07	86/09
PHOS-TOT	MG/L P			4	5.565000	4.394500	12.150	3.090	86/07	86/09
TOT HARD	CACO3	MG/L		4	229.5000	31.94300	260	199	86/07	86/09
CALCIUM	CA-TOT	MG/L		4	64.52500	9.283600	73.6	54.7	86/07	86/09
MGNSIUM	MG,TOT	MG/L		4	16.62500	2.260500	18.6	14.2	86/07	86/09
BARIUM	BA,TOT	UG/L	K	4	200.0000	.0000000	200	200	86/07	86/09
CHROMIUM	CR,TOT	UG/L	K	4	30.00000	.0000000	30	30	86/07	86/09
COPPER	CU,TOT	UG/L		1	10.00000		10	10	86/07	86/07
			K	3	10.00000	.0000000	10	10	86/07	86/09
			T	4	10.00000	.0000000	10	10	86/07	86/09
IRON	FE,TOT	UG/L		4	315.0000	95.39400	410	210	86/07	86/09
LEAD	PB,TOT	UG/L		4	4.750000	1.707800	7	3	86/07	86/09
NICKEL	NI,TOTAL	UG/L	K	4	40.00000	.0000000	40	40	86/07	86/09
ZINC	ZN,TOT	UG/L		3	30.00000	8.660300	40	25	86/07	86/09
			K	1	10.00000		10	10	86/09	86/09
			T	4	25.00000	12.24800	40	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	K	4	500.0000	.0000000	500	500	86/07	86/09
FEC COLI	MFM-FCBR	/100ML		1	25.00000		25	25	86/07	86/07
RESIDUE	DISS-180 C	MG/L		3	543.6700	52.59900	598	493	86/07	86/09
BOD 20C	5DAY CAR	MG/L		1	11.00000		11.0	11.0	86/07	86/07
BOD 20C	20DAYCAR	MG/L		1	47.00000		47.0	47.0	86/07	86/07

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Table C-4 (Continued).

STORET STATION NUMBER U05W06
 LATITUDE/LONGITUDE 41 19 01/82 59 08
 RACCOON CREEK JUST UPST CLYDE WWTP OUTFALL
 RIVER MILE 11.01

PARAMETER			R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END
WATER	TEMP	CENT		3	24.70000	1.374700	25.9	23.2	86/07	86/09
STREAM	FLOW,	INST-CFS		3	1.083300	.3178600	1	.8	86/07	86/09
CNDUCTVY	AT 25C	MICROMHO		3	1303.300	209.8400	1540	1140	86/07	86/09
DO	PROBE	MG/L		3	3.100000	1.646200	5.0	2.1	86/07	86/09
BOD	5 DAY	MG/L		1	30.00000		30.0	30.0	86/07	86/07
BOD	20 DAY	MG/L		1	65.00000		65.0	65.0	86/07	86/07
COD	LOWLEVEL	MG/L		3	100.6700	43.40900	149.0	65.0	86/07	86/09
PH		SU		3	8.000000	.6084200	8.70	7.60	86/07	86/09
RESIDUE	TOT NFLT	MG/L		2	7.500000	2.121300	9	6	86/07	86/09
			K	1	5.000000		5	5	86/08	86/08
			T	3	6.666700	2.081700	9	5	86/07	86/09
OIL-GRSE	FREON-GR	MG/L		1	3.090000		3.09	3.09	86/07	86/07
NH3+NH4-	N TOTAL	MG/L		3	1.806700	1.077100	2.920	.770	86/07	86/09
NO2-N	TOTAL	MG/L		3	2.040000	1.040600	3.100	1.020	86/07	86/09
TOT KJEL	N	MG/L		3	5.333300	1.242300	6.100	3.900	86/07	86/09
NO2&NO3	N-TOTAL	MG/L		2	3.805000	1.647600	4.97	2.64	86/07	86/08
PHOS-TOT		MG/L P		3	1.516700	1.533100	3.280	.500	86/07	86/09
TOT HARD	CACO3	MG/L		3	373.6700	176.2100	566	220	86/07	86/09
CALCIUM	CA-TOT	MG/L		3	100.1000	56.38300	163.0	54.1	86/07	86/09
MGNSIUM	MG,TOT	MG/L		3	29.96700	8.979100	38.5	20.6	86/07	86/09
BARIUM	BA,TOT	UG/L	K	3	200.0000	.0000000	200	200	86/07	86/09
CHROMIUM	CR,TOT	UG/L	K	3	30.00000	.0000000	30	30	86/07	86/09
COPPER	CU,TOT	UG/L		1	60.00000		60	60	86/07	86/07
			K	2	10.00000	.0000000	10	10	86/08	86/09
			T	3	26.66700	28.86800	60	10	86/07	86/09
IRON	FE,TOT	UG/L		3	320.0000	235.1600	590	160	86/07	86/09
LEAD	PB,TOT	UG/L	K	3	2.000000	.0000000	2	2	86/07	86/09
NICKEL	NI,TOTAL	UG/L		2	135.0000	35.35500	160	110	86/07	86/08
			K	1	40.00000		40	40	86/09	86/09
			T	3	103.3300	60.27700	160	40	86/07	86/09
ZINC	ZN,TOT	UG/L		1	90.00000		90	90	86/07	86/07
			K	2	10.00000	.0000000	10	10	86/08	86/09
			T	3	36.66700	46.18800	90	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	K	3	500.0000	.0000000	500	500	86/07	86/09
FEC COLI	MFM-FCBR	/100ML		1	9200.000		9200	9200	86/07	86/07
RESIDUE	DISS-180	C	MG/L	3	894.6700	255.7700	1190	746	86/07	86/09
BOD	20C 5DAY CAR	MG/L		1	26.00000		26.0	26.0	86/07	86/07
BOD	20C 20DAYCAR	MG/L		1	49.00000		49.0	49.0	86/07	86/07

Table C-4 (Continued).

STORET STATION NUMBER U05W03
 LATITUDE/LONGITUDE 41 18 31/82 59 10
 WHIRLPOOL 001 OUTFALL TO RACCOON CREEK
 RIVER MILE 11.61

PARAMETER		R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END
WATER	TEMP	CENT	3	32.16700	.2904300	32.5	32.0	86/07	86/09
CNDUCTVY	AT 25C	MICROMHO	4	2355.000	579.4500	3000	1650	86/07	86/09
DO	PROBE	MG/L	3	5.600000	.5001000	6.1	5.1	86/07	86/09
BOD	5 DAY	MG/L	2	73.50000	27.57700	93.0	54.0	86/07	86/07
BOD	20 DAY	MG/L	1	220.0000		220.0	220.0	86/07	86/07
COD	LOWLEVEL	MG/L	4	261.7500	89.48900	380.0	165.0	86/07	86/09
PH		SU	3	9.300000	.1000500	9.40	9.20	86/07	86/09
RESIDUE	TOT NFLT	MG/L	4	9.250000	2.753800	12	6	86/07	86/09
OIL-GRSE	FREON-GR	MG/L	1	8.120000		8.12	8.12	86/07	86/07
NH3+NH4-	N TOTAL	MG/L	4	.9675000	.1668100	1.080	.720	86/07	86/09
N02-N	TOTAL	MG/L	4	5.625000	1.767100	7.400	3.200	86/07	86/09
TOT KJEL	N	MG/L	4	10.45000	5.327600	18.000	5.600	86/07	86/09
N02&N03	N-TOTAL	MG/L	4	9.315000	3.672200	12.20	3.96	86/07	86/09
PHOS-TOT		MG/L P	4	1.275000	.1912300	1.500	1.050	86/07	86/09
TOT HARD	CACO3	MG/L	4	754.5000	364.5400	1130	336	86/07	86/09
CALCIUM	CA-TOT	MG/L	4	206.0800	114.4000	319.0	66.3	86/07	86/09
MGNSIUM	MG,TOT	MG/L	4	58.10000	19.89400	80.3	41.1	86/07	86/09
BARIUM	BA,TOT	UG/L	4	322.5000	45.00000	380	270	86/07	86/09
CHROMIUM	CR,TOT	UG/L	K	4 30.00000	.0000000	30	30	86/07	86/09
COPPER	CU,TOT	UG/L	4	51.25000	23.93600	85	30	86/07	86/09
IRON	FE,TOT	UG/L	4	617.5000	355.1900	1040	210	86/07	86/09
LEAD	PB,TOT	UG/L	K	2 2.000000	.0000000	2	2	86/08	86/09
NICKEL	NI,TOTAL	UG/L	4	317.5000	73.20100	380	240	86/07	86/09
ZINC	ZN,TOT	UG/L	3	51.66700	59.23100	120	15	86/07	86/08
			K	1 10.00000		10	10	86/09	86/09
			T	4 41.25000	52.65900	120	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	1	340.0000		340	340	86/08	86/08
			K	2 500.0000	.0000000	500	500	86/07	86/07
			T	3 446.6700	92.37700	500	340	86/07	86/08
FEC COLI	MFM-FCBR /100ML		K	1 3.000000		3	3	86/07	86/07
RESIDUE	DISS-180 C	MG/L	3	1953.300	673.3800	2410	1180	86/07	86/09
BOD	20C 5DAY CAR	MG/L	1	75.00000		75.0	75.0	86/07	86/07
BOD	20C 20DAYCAR	MG/L	1	165.0000		165.0	165.0	86/07	86/07

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Table C-4 (Continued).

STORET STATION NUMBER U05W02
 LATITUDE/LONGITUDE 41 18 26/82 59 09
 RACCOON CREEK AT CLYDE - END OF SPRING ST.
 RIVER MILE 11.70

PARAMETER		R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END	
WATER	TEMP	CENT	3	19.60000	.7549500	20.3	18.8	86/07	86/09	
STREAM	FLOW,	INST-CFS	3	.3000000	.3011700	.6	.04	86/07	86/09	
CNDUCTVY	AT 25C	MICROMHO	2	886.0000	97.58100	955	817	86/07	86/09	
DO	PROBE	MG/L	3	8.566700	2.173300	10.9	6.6	86/07	86/09	
BOD	5 DAY	MG/L	1	1.100000		1.1	1.1	86/07	86/07	
BOD	20 DAY	MG/L	1	2.500000		2.5	2.5	86/07	86/07	
COD	LOWLEVEL	MG/L	1	29.00000		29.0	29.0	86/09	86/09	
		K	2	20.00000	.0000000	20.0	20.0	86/07	86/08	
		T	3	23.00000	5.196200	29.0	20.0	86/07	86/09	
PH	SU		3	7.816700	.2020900	8.00	7.60	86/07	86/09	
RESIDUE	TOT NFLT	MG/L	1	54.00000		54	54	86/08	86/08	
		K	2	5.000000	.0000000	5	5	86/07	86/09	
		T	3	21.33300	28.29000	54	5	86/07	86/09	
OIL-GRSE	FREON-GR	MG/L	K	1	1.000000	1.00	1.00	86/07	86/07	
NH3+NH4-	N TOTAL	MG/L	1	.0700000		.070	.070	86/09	86/09	
		K	2	.0500000	.0000000	.050	.050	86/07	86/08	
		T	3	.0566670	.0115470	.070	.050	86/07	86/09	
N02-N	TOTAL	MG/L	3	.0500000	.0100000	.060	.040	86/07	86/09	
TOT KJEL	N	MG/L	3	.6333300	.1527600	.800	.500	86/07	86/09	
N02&N03	N-TOTAL	MG/L	3	1.786700	1.235800	3.15	.74	86/07	86/09	
PHOS-TOT	MG/L P		3	.1400000	.0264580	.160	.110	86/07	86/09	
TOT HARD	CACO3	MG/L	3	356.0000	33.15100	393	329	86/07	86/09	
CALCIUM	CA-TOT	MG/L	3	107.0000	9.539400	118.0	101.0	86/07	86/09	
MGNSIUM	MG,TOT	MG/L	3	21.53300	2.663300	23.8	18.6	86/07	86/09	
BARIUM	BA,TOT	UG/L	K	3	200.0000	.0000000	200	200	86/07	86/09
CHROMIUM	CR,TOT	UG/L	K	3	30.00000	.0000000	30	30	86/07	86/09
COPPER	CU,TOT	UG/L	K	3	10.00000	.0000000	10	10	86/07	86/09
IRON	FE,TOT	UG/L	3	643.3300	597.6900	1330	240	86/07	86/09	
LEAD	PB,TOT	UG/L	K	3	2.000000	.0000000	2	2	86/07	86/09
NICKEL	NI,TOTAL	UG/L	K	3	40.00000	.0000000	40	40	86/07	86/09
ZINC	ZN,TOT	UG/L	K	3	10.00000	.0000000	10	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	1	790.0000		790	790	86/08	86/08	
		K	2	500.0000	.0000000	500	500	86/07	86/09	
		T	3	596.6700	167.4300	790	500	86/07	86/09	
FEC COLI	MFM-FCBR	/100ML	1	2000.000		2000	2000	86/07	86/07	
RESIDUE	DISS-180 C	MG/L	3	601.3300	21.01200	622	580	86/07	86/09	
BOD	20C 5DAY CAR	MG/L	K	1	1.000000		1.0	1.0	86/07	86/07
BOD	20C 20DAYCAR	MG/L	1	1.800000		1.8	1.8	86/07	86/07	

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Table C-5. Concentrations of heavy metals in sediments of the Raccoon Creek study area, 1986. All parameter concentrations, excluding nickel, were ranked based on a stream sediment classification system described by Kelly and Hite (1984).

<u>Stream Name</u>	<u>Sediment Concentration (mg/kg dry weight)</u>					
	River Mile	Cadmium	Chromium	Copper	Lead	Nickel
Raccoon Creek						
13.2	0.10 ^a	5 ^a	7 ^a	7 ^a	9	35 ^a
10.2	0.51 ^b	13 ^a	30 ^a	290 ^a	41	373 ^e
3.1	0.43 ^a	8 ^a	8 ^a	17 ^a	19	48 ^a

^a Non-elevated.

^b Slightly elevated.

^c Elevated.

^d Highly elevated.

^e Extremely elevated.

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Table C-4 (Continued).

STORET STATION NUMBER U05S01
 LATITUDE/LONGITUDE 41 17 17/82 58 57
 RACCOON CREEK UPST CLYDE - LIMERICK RD.
 RIVER MILE 13.60

PARAMETER		R	NO	MEAN	STAN DEV	MAXIMUM	MINIMUM	BEG	END
WATER	TEMP	CENT	3	18.83300	1.893100	21.0	17.5	86/07	86/09
STREAM	FLOW,	INST-CFS	5	.1620000	.1825400	.5	0	86/07	86/09
CNDUCTVY	AT 25C	MICROMHO	3	891.0000	181.6800	1090	734	86/07	86/09
DO	PROBE	MG/L	3	4.266700	2.055100	6.4	2.3	86/07	86/09
PH		SU	3	7.366700	.7572700	7.90	6.50	86/07	86/09
NH3+NH4-	N TOTAL	MG/L	3	.4333300	.1418900	.560	.280	86/07	86/09
NO2-N	TOTAL	MG/L	3	.1200000	.0000000	.120	.120	86/07	86/09
TOT KJEL	N	MG/L	3	1.100000	.2645800	1.300	.800	86/07	86/09
NO2&NO3	N-TOTAL	MG/L	3	1.863300	1.566700	3.67	.88	86/07	86/09
PHOS-TOT		MG/L P	3	.2633300	.1171900	.350	.130	86/07	86/09
TOT HARD	CACO3	MG/L	3	363.3300	47.60700	418	331	86/07	86/09
CALCIUM	CA-TOT	MG/L	3	108.7700	14.45300	125.0	97.3	86/07	86/09
MGNSIUM	MG,TOT	MG/L	3	22.30000	3.122500	25.8	19.8	86/07	86/09
COPPER	CU,TOT	UG/L	1	130.0000		130	130	86/07	86/07
		K	2	10.00000	.0000000	10	10	86/08	86/09
		T	3	50.00000	69.28200	130	10	86/07	86/09
IRON	FE,TOT	UG/L	3	426.6700	124.2300	570	350	86/07	86/09
NICKEL	NI,TOTAL	UG/L	K	3 40.00000	.0000000	40	40	86/07	86/09
ZINC	ZN,TOT	UG/L	2	22.50000	3.535500	25	20	86/07	86/09
		K	1	10.00000		10	10	86/08	86/09
		T	3	18.33300	7.637700	25	10	86/07	86/09
ALUMINUM	AL,TOT	UG/L	K	3 500.0000	.0000000	500	500	86/07	86/09

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Table C-7. Fecal coliform counts (number/100 ml) from samples collected at 6 sites in Raccoon Creek on July 24, 1986.

Station	RM	Fecal Coliform/100 ml
Spring Street	11.7	2000
Whirlpool effluent	11.6	<3
Upstream Clyde WWTP	11.1	9200*
Clyde WWTP Effluent	11.0	25
T.R. 223	10.2	480
T.R. 229	8.7	280

* exceeds 2000/100 ml primary contact recreation WQS.

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Table C-6. Diurnal D.O. (mg/l) concentrations measured on July 27, 1986, at 7 sites in Raccoon Creek.

Station	RM	Time	D.O.	°C	Time	D.O.	°C	Time	D.O.	°C
US 6	3.1	0700	4.5	21.5	1250	7.2	23.0	1705	9.4	25.5
SR 412	6.5	0711	3.4	20.2	1300	5.1	21.5	1715	5.5	23.0
TR 229	8.7	0722	3.2	22.2	1315	4.2	24.2	1725	4.2	25.1
TR 223	10.2	0730	1.2	22.2	1320	3.7	26.0	1735	3.7	25.8
UST WWTP	11.1	0740	1.4	24.6	1330	4.7	26.2	1743	2.6	25.8
Spring Street	11.7	0747	5.1	20.8	1340	8.0	23.2	1750	6.2	23.2
Limerick Road	13.2	0755	4.3	21.0	1350	6.7	23.6	1800	6.4	24.4